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Question No 1.
A.

Answer:

* Elements of Hydropower Plant:

→ Hydropower plants convert the potential energy of water head to mechanical energy by using a hydraulic turbine. the hydro-turbines are in turn connected to a generator that converts the mechanical energy to electric energy.

* Elements:

1. Forebay:

A forebay is a basin area of hydropower plant where water is temporarily stored before going into chamber. Reservoirs are built across the rivers to store the water, the water stored on upstream side of dam can be carried by penstocks to the power house. In this case, the reservoir itself acts as forebay.

2. Intake structure:

It is a structure which collects the water from the forebay and directs it into the penstocks. It contain some components of which trash racks plays vital role. trash racks are provided at the entrance of penstock to trap the debris in the water.

3. Penstock:

Penstocks are like large pipes laid with some slope which carries water from intake structure or reservoir to turbines. these are designed to resist the water hammer effect. It is made from steel or reinforced concrete.

4. Surge chamber:

A surge chamber or tank is a cylindrical tank which is open at the top to control the pressure in penstock. It is connected to the penstock and as close as possible to the power house.

whenever the power house rejected the water load coming from penstock the water level in the surge tank rises and control the pressure in penstock.

5. Hydraulic turbines:

A device which can convert the hydraulic energy into the mechanical energy which again converted into electrical energy by coupling the shaft of turbine to the generator.

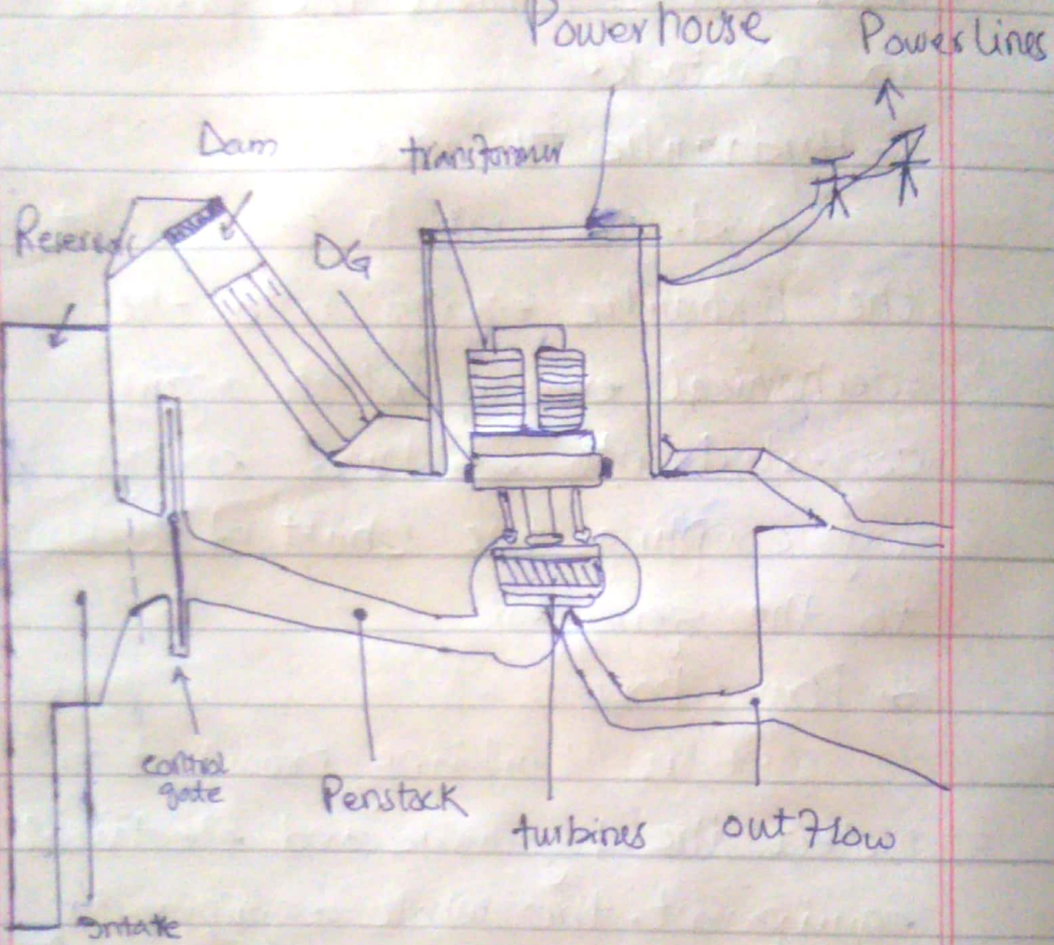
6. Power house:

It is building provided to protect the hydraulic and electrical equipment. the whole equipment is supported by the foundation or substructure laid for the power house.

7. Tailrace:

Tailrace is the flow of water from turbines to stream. this is because of silting or scouring caused by unnecessary flow of water from power house. Hence, proper design of tailrace should be more important.

* **Diagram:**



Question No 1.

(b).

Solution: Given that

Available volume at pondage $= V = 5 \times 10^5 \, m^3$

Available head: $h = 100m$

Hydraulic efficiency: $85\% = 0.85$

electrical e efficiency: 0.94

therefore

overall efficiency $= 0.85 \times 0.94 = 0.80$

Using: $E = \eta \rho g h V = 0.8 \times 1000 \times 9.81 \times 100 \times 5 \times 10^5$

$E = 3.92 \times 10^{11}$ W-s

Question No 2.

(A).

Answer:

Types of Hydropower turbines:

There are two main types of hydro turbines: Impulse and reaction.

* **Impulse turbine:**

It generally uses the velocity of water to move the runner and discharges to atmospheric pressure. It is suitable for high head, low flow applications.

→ **Pelton:**

A pelton wheel has one or more free jets and impinging on the buckets of a runner. Draft tubes are not required for impulse turbine since the runner must be located above the maximum watertail to permit operation at atmospheric pressure.

→ Cross Flow:

It is drum-shaped and uses an elongated, rectangular-section nozzle directed against curved vanes on a cylindrically shaped runner. the cross-flow turbines allows the water to flow through the blades twice. the cross-flow was developed to accommodate larger water flows and lower heads than the pelton.

* Reaction turbine:

A reaction turbine develops power from the combined action of pressure and moving water. the runner is placed directly in the water stream flowing over the blades rather than striking each individually. It is used for sites with lower head and higher flows.

→ Propeller:

It has a runner with three to six blades in which the water contacts all the blades constantly. the pitch of blades may be fixed or adjostable. It has several types.

→ Bulb turbines

the turbine and generator are a sealed unit placed directly in the water stream.

→ Straflo:

the generator is attached directly to the perimeter of the turbine.

→ Tube turbines

The penstock bends just before or after the runner, allowing a straight line connection to the generator.

→ Kaplan:

Both the blades and the wicket gates are adjustable, allowing for a wider range of operation.

→ Francis:

It has a runner with fixed buckets (vanes), usually nine or more. water is introduced just above the runner and all around it and then falls through, causing it to spin.

→ Kinetic:

It is also called as free-flow turbines, generate electricity from the kinetic energy present in flowing water rather than potential energy from the head.

* Parameters:

1. head.
2. Specific speed.
3. Rotational speed.
4. Efficiency of the turbine.
5. Cavitation.
6. Disposition of turbine shaft.
7. Part load operation.

Question No 3.

Answer:

Nuclear fuel cycle:

1. Mining & Milling:

→ Uranium is usually mined by either surface (open cut) or underground mining techniques, depending on the depth at which the ore body is found.

→ From these, the mined uranium

ore is sent to a mill which is usually located close to the mine.

→ At the mill the ore is crushed and ground to a fine slurry which is leached in sulfuric acid to allow the separation of uranium from the waste rock.

→ It is then recovered from solution as uranium oxide (U_3O_8) concentrate.

2. Conversion:

→ Because uranium needs to be in the form of a gas before it can be enriched, the U_3O_8 is converted into gas uranium hexafluoride (UF_6) at a conversion plant.

3. Enriching:

→ Need to enrich uranium to at least 3% for a power plant.

→ two methods.

• Gaseous Diffusion Method

UF_6 (hexfluoride) gas heated

U-238 is heavier than U-235

hexafluoride gas can be separated into two streams.

Low velocity U-238

high velocity U-235

- Centrifuge Method
  Gas spun in centrifuge
  Lighter U-235 will separate from heavier U-238

4. <u>Fuel Conversion:</u>

→ Enriched Uranium transported to a fuel fabrication plant where it is converted to uranium dioxide (UO_2) powder and pressed into small pellets.

→ These pellets are inserted into thin tubes, usually of a zirconium alloy or stainless steel, to form fuel rods.

→ The rods are then sealed and assembled in cluster to form fuel assemblies for use in the core of the nuclear reactor.

5. <u>The Reactor Core:</u>

→ The reactor core consists of fuel rods and control rods

→ Fuel rods contain enriched uranium

→ Control rods are inserted between the fuel rods to absorb neutrons and slow the chain reaction.

→ CR are made of Cadmium, which absorb neutrons.

6. Moderators:

→ Neutrons produced during fission in the core are moving too fast to cause a chain reaction

→ A moderator is required to slow down the neutrons.

→ In nuclear Power Plants water or graphite acts as moderator.

7. Light Vs. Heavy Water:

→ 99.99% of water molecules contain hydrogen.

→ Water can be specially prepared so that the molecules contain deuterium.

→ Normal water is called light water while containing deuterium is called heavy water.

→ Heavy water is much better moderator but is very expansive to make.

8. Boiling Water Reactor:

→ Heat generated in the core is used to generated stream through a heat exchanger.

→ The stream runs a turbine just like a normal power plant.

9. <u>Pressurized Water Reactors:</u>

→ Water in the core heated top 325°c but is not turned into stream due to high pressure in the primary loop.

→ Heat exchanger used to transfer heat into secondary loop, water is turned to steam to power turbine.

→ Steam used to power turbine never comes directly in contact with radioactive materials.

10. <u>Uranium Reprocessing:</u>

→ Spent fuel still contains approx 96% of its original uranium, of which the fissionable U-235 content has been reduced to less than 1%.

→ Spent fuel comprises waste products and the remaining 1% is plutonium produced while the fuel was in the reactor.

→ Reprocessing extracts useable fissile U-238.

→ Most of the spent fuel can be reprocessed.

11. Nuclear Waste Disposal:

→ In the US, no high-level nuclear waste is ever disposed of it sits in specially designed pools resembling large swimming pools (water cools the fuel and acts as a radiation shield) or in special designed dry storage containers.

→ Spent nuclear fuel most be isolated for thousands of years.

→ After 10,000 years of radioactive decay, according to EPA standards, the spent nuclear fuel will no longer pose a threat to public health.

Question No 2.

(b).

Solution: Given data

$h = 100\ m$

$A = 2.2\ m^2/s$

$e = 85\%$

$N_s = 85.49/(n)$

Diameter $= 38.56\sqrt{h}/n$

$q = (\pi d_j^2) v_j/4$

Where $v_j = \sqrt{2gh}$

As we know that

Diameter = $38.56 \sqrt{h}/n$

$= 38.56 \times 16216$

$D = 625.28896m$

Jet diameter

$q = (3.14 \times 625.288) 6102/4$

$q = 24951.7 . m$